

### REMARKS

Claims 1-20 and 46-73 were previously filed in this patent application. Applicants have withdrawn claims 13-45. Claims 6, 46, 56, 60, and 72 are currently amended. Claims 1-12, 47-55, 57-59, 61-71, and 73 are as originally presented.

Applicants affirm that no new matter has been added to the patent application. Claim 6 has been rewritten to provide for the correct punctuation of the claim — as originally written, Claim 6 did not end in a period. Claims 46 and 60 have been amended to further limit the invention claimed therein to a coiled carbon nanotube and product of manufacture that has a non-hexagonal/hexagonal carbon ring ratio in the range of 0.1:1 to 1:1. Support is provided by original claim 1 and by the paragraph beginning on page 8, line 5 through line 15. Claims 56 and 72 have been amended to correct the misspelling of the word “controlling.”

Accordingly, Applicants hereby request careful reconsideration of this patent application in view of the following comments.

### RESPONSE TO 35 U.S.C. § 102 REJECTIONS

#### **Claims 1-12 and 46-73**

Claims 1-12<sup>1</sup> and 46-73 were rejected under 35 U.S.C. § 102(a) as being anticipated by *Biro et al.* (Phys. Review, Oct. 2002). The Examiner states that “Biro teaches coiled carbon nanotubes with substantially uniform diameter and distance between coils throughout its length. A ratio of 1:1 is taught (page 5, last paragraph of discussion) and it is taught that a ratio of 0.1:1 is known in the art (page 1, 2<sup>nd</sup> column). While Biro does not mention the diameter or the distance between coils, nanotube to one of skill in the art means diameters less than 100 nm.”

Applicants respectfully request withdrawal of the § 102 rejection since it is believed that the claims define patentability over Biro. In pending claims 46 and 60, the phrase “having a non-hexagonal/hexagonal carbon ring ratio in the range of 0.1:1 to 1:1” has been added to further

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<sup>1</sup> Applicants note that in the Non-Final Office Action of July 11, 2006, the Examiner incorrectly rejected claim 21 at the bottom of page 3. Claim 21 is part of the non-elected invention and has been withdrawn from further consideration in this patent application.

limit the claimed invention. Applicants assert that Biro fails to disclose a coiled carbon nanotube having a non-hexagonal/hexagonal carbon ring ratio in the range of 0.1:1 to 1:1. On page 1, beginning at the bottom of the 1<sup>st</sup> column and ending in the middle of the 2<sup>nd</sup> column, Biro provides:

"The torodial, coiled, and Y-branched carbon nanotubes were *predicted theoretically* soon after the discovery of the straight nanotubes. All these structures are based on the insertion of nonhexagonal (n-Hx) defects in the seamless hexagonal (Hx) network.... A general characteristic of the above coil models is that the ratio n-Hx to Hx is far less than unity. For example, in the case of a single Dunlap knee connecting (3,3) to (6,0) nanotubes with a bend of 30° when the smallest possible number of Hx rings is used, the ratio n-Hx/Hx is 0.125. A torus can be built by joining together 12 such knees. C<sub>540</sub> is the smallest torus made of connected (6,0) and (3,3) segments giving n-Hx/Hx = 0.098. Larger torus diameter can be produced by adding six rows of armchair hexagons to increase the distance between the knees, this will yield an even lower n-hx/Hx ratio...." (emphasis added).

Biro specifically discloses a Dunlap knee and torus with non-hexagonal/hexagonal ratios between 0.1:1 and 1:1. It does not specifically disclose a coiled carbon nanotube within similar non-hexagonal/hexagonal ratios. A Dunlap knee is a junction of two straight carbon nanotubes bent at an angle of about 30°. See B.I. Dunlap, Phys. Rev. B 46, 1933 (1992). A torus is a doughnut-shaped surface created by revolving a circle in three-dimensional space about an axis coplanar with the circle. Neither a Dunlap knee nor a torus can be considered a coil.

Furthermore, Biro refers to coiled carbon nanotubes being *theoretically predicted*, it does not describe such structures as actually existing. Nor does Biro adequately explain how such theoretical coiled carbon nanotubes could be created. See *Elan Pharmaceuticals, Inc. v. Mayo Foundation for Medical Education and Research*, 346 F.3d 1051, 1055 (Fed. Cir. 2003) ("It is insufficient to name or describe the desired subject matter, if it cannot be produced without undue experimentation.").

In addition, Biro does not teach a coiled carbon nanotube with a non-hexagonal/hexagonal ratio of 1:1. The last paragraph of the Discussion on page 5 begins:

"Taking into account that the helically coiled carbon nanotubes constructed with n-Hx to Hx ratio around or over 1 exhibit a remarkable structural stability with respect to defects..."

This reference does not specifically teach a ratio of 1:1 nor does it enable one skilled in the art to produce such a product. In sum, the invention claimed in Claims 1-12 and 46-73 are not anticipated by Biro because Biro fails to disclose a coiled carbon nanotube having a non-hexagonal/hexagonal carbon ring ratio in the range of 0.1:1 to 1:1.

Claims 46-73 were rejected under 35 U.S.C. § 102(b) as being anticipated by Volodin *et al.* (Phy. Review Letters, April 2000). The Examiner states that "Volodin teaches coiled carbon nanotubes with substantially uniform diameter and distance between coils throughout its length (Fig. 2), diameters of less than 100 nm, and distance between coils of less than 200 nm (Table I)."

Applicants respectfully request withdrawal of the § 102 rejection since it is believed that the claims define patentability over Volodin. In pending claims 46 and 60, the phrase "having a non-hexagonal/hexagonal carbon ring ratio in the range of 0.1:1 to 1:1" has been added to further limit the claimed invention. Applicants assert that Volodin fails to disclose a coiled carbon nanotube having a non-hexagonal/hexagonal carbon ring ratio in the range of 0.1:1 to 1:1. In the second paragraph of page 1 Volodin provides:

"The intrinsic curvature of catalytically grown nanotubes is likely to occur without a very large elastic strain being involved. At this point, it is not clear whether a coiled growth mechanism involves the presence of specific atomic scale defects.... The coiling can result from the introduction of pentagon-heptagon pairs at regular distances in the hexagonal network forming the wall of a straight carbon nanotube. The question remains why such defects appear periodically to form the helical structure."

Nowhere does Volodin disclose a coiled carbon nanotube having a non-hexagonal/hexagonal ratio in the range of 0.1:1 to 1:1. "[I]nvalidity by anticipation requires that the four

corners of a single, prior art document *describe every element of the claimed invention*, either expressly or inherently, such that a person of ordinary skill in the art could practice the invention without undue experimentation.” *Advanced Display Systems, Inc. v. Kent State University*, 212 F.3d 1272, 1282 (Fed. Cir. 2000) (emphasis added). Because a non-hexagonal/hexagonal ratio in the range of 0.1:1 to 1:1 is an element of the claimed invention, and that element is not described expressly or inherently in Volodin, Volodin fails to anticipate the present invention under § 102(b).

Claims 1-12 and 46-73 were rejected under 35 U.S.C. § 102(b) as being anticipated by Amelinckx *et al.* (Science, July 1994). The Examiner states in paragraph number 7 that “Amelinckx teaches coiled carbon nanotubes with substantially uniform diameter and distance between coils throughout its length (Fig. 1), diameters of less than 100 nm, and distance between coils of less than 200 nm (Fig. 1).” He states in paragraph number 8 that “Amelinckx teaches coiled carbon nanotubes with substantially uniform diameter and distance between coils throughout its length, but does not teach the non-hexagonal to hexagonal ratio of the coils.”

Applicants respectfully request withdrawal of the § 102 rejection since it is believed that the claims define patentability over Amelinckx. In pending claims 46 and 60, the phrase “having a non-hexagonal/hexagonal carbon ring ratio in the range of 0.1:1 to 1:1” has been added to further limit the claimed invention. Nowhere does Amelinckx disclose a coiled carbon nanotube having a non-hexagonal/hexagonal ratio in the range of 0.1:1 to 1:1. In fact, the Examiner states in paragraph number 8 that Amelinckx “does not teach the non-hexagonal to hexagonal ratio of the coils.” “[I]nvalidity by anticipation requires that the four corners of a single, prior art document *describe every element of the claimed invention*, either expressly or inherently, such that a person of ordinary skill in the art could practice the invention without undue experimentation.” *Advanced Display Systems, Inc. v. Kent State University*, 212 F.3d 1272, 1282 (Fed. Cir. 2000) (emphasis added). Because a non-hexagonal/hexagonal ratio in the range of 0.1:1 to 1:1 is an element of the claimed invention, and that element is not described expressly or inherently in Amelinckx, Amelinckx fails to anticipate the present invention under § 102(b).

Claims 1-12 and 46-73 were rejected under 35 U.S.C. § 102(a) as being anticipated by Pan *et al.* (J. of App. Phys., June 2002). In paragraph number 9 of the July 11<sup>th</sup> Office Action, the Examiner states "Pan teaches coiled carbon nanotubes with substantially uniform diameter and distance between coils of less than 200 nm (Fig. 2)." In paragraph number 10, he states "Pan teaches coiled carbon nanotubes with substantially uniform diameter and distance between coils throughout its length, but does not teach the non-hexagonal to hexagonal ratio of the coils."

Applicants respectfully request withdrawal of the § 102 rejection since it is believed that the claims define patentability over Pan. In pending claims 46 and 60, the phrase "having a non-hexagonal/hexagonal carbon ring ratio in the range of 0.1:1 to 1:1" has been added to further limit the claimed invention. Nowhere does Pan disclose a coiled carbon nanotube having a non-hexagonal/hexagonal ratio in the range of 0.1:1 to 1:1. In fact, the Examiner states in paragraph number 10 that Pan "does not teach the non-hexagonal to hexagonal ratio of the coils." "[I]nvalidity by anticipation requires that the four corners of a single, prior art document *describe every element of the claimed invention*, either expressly or inherently, such that a person of ordinary skill in the art could practice the invention without undue experimentation." *Advanced Display Systems, Inc. v. Kent State University*, 212 F.3d 1272, 1282 (Fed. Cir. 2000) (emphasis added). Because a non-hexagonal/hexagonal ratio in the range of 0.1:1 to 1:1 is an element of the claimed invention, and that element is not described expressly or inherently in Pan, Pan fails to anticipate the present invention under § 102(b).

Claims 1-12 and 46-73 were rejected under 35 U.S.C. 102(c) and being anticipated by Nakayama *et al.* (6,558,645). In paragraph number 11, the Examiner states "Nakayama teaches coiled carbon nanotubes with substantially uniform diameter and distance between coils throughout its length, diameters of less than 100 nm, and distance between coils of less than 200 nm (Fig. 3 & 6)." In paragraph number 12, he states "Nakayama teaches coiled carbon nanotubes with substantially uniform diameter and distance between coils throughout its length, but does not teach the non-hexagonal to hexagonal ratio of the coils."

Applicants respectfully request withdrawal of the § 102 rejection since it is believed that the claims define patentability over Nakayama. In pending claims 46 and 60, the phrase "having a non-hexagonal/hexagonal carbon ring ratio in the range of 0.1:1 to 1:1" has been added to

further limit the claimed invention. Nowhere does Nakayama disclose a coiled carbon nanotube having a non-hexagonal/hexagonal ratio in the range of 0.1:1 to 1:1. In fact, the Examiner states in paragraph number 10 that Nakayama "does not teach the non-hexagonal to hexagonal ratio of the coils." "To anticipate a claim, a prior art reference must disclose every limitation of the claimed invention, either explicitly or inherently." *Atlas Powder Co. v. Ireco, Inc.*, 190 F.3d 1342, 1346 (Fed. Cir. 1999). Because a non-hexagonal/hexagonal ratio in the range of 0.1:1 to 1:1 is an element of the claimed invention, and that element is not disclosed expressly or inherently in Nakayama, Nakayama fails to anticipate the present invention under § 102(b).

In view of the foregoing, it is respectfully submitted that Applicants' claims 1-12 and 46-73 (as currently amended) are not properly rejectable as anticipated by Biro, Volodin, Amelinckx, Pan, or Nakayama '645.

#### **RESPONSE TO 35 U.S.C. §103 REJECTIONS**

##### **Claims 1-12 and 46-73**

The Examiner rejected claims 1-12 and 46-73 under 35 U.S.C. §103(a) as being obvious over Biro *et al.* (Phys. Review, Oct. 2002). Applicants submit that the novel physical features of claims 1-12 and 46-73 (as currently amended) are nonobvious and hence patentable under §103 since Applicants' invention represents a departure from the teachings of Biro.

"[S]ection 103 requires assessment of the invention as a whole. This 'as a whole' assessment of the invention requires a showing that an artisan of ordinary skill in the art at the time of invention, confronted by the same problems as the inventor and with no knowledge of the claimed invention, would have selected the various elements from the prior art and combined them in the claimed manner." *Princeton Biochemicals, Inc. v. Beckman Coulter, Inc.*, 411 F.3d 1332, 1337 (Fed. Cir. 2005). One of ordinary skill in the art would not have selected the various elements from Biro to create a coiled carbon nanotube having a non-hexagonal/hexagonal carbon ring ratio in the range of 0.1:1 to 1:1. Biro examines "the possibility of building regular, helically coiled carbon nanotubes with n-Hx/Hx ratio higher than unity." (Page 1, column 2) In

addition, Biro states "When comparing the cohesion energies calculated using the Tersoff-Brenner potential for graphene (-7.37 eV/atom), C60 (-6.85 eV/atom), and the coil shown in Fig. 6(b) (-6.66 eV/atom, average over the three-fold coordinated atoms thus excluding the ending atoms), one may conclude that the coils built *using a n-Hx/Hx ratio higher than 1 are energetically possible.*" (Page 5, columns 1-2) (emphasis added) Biro actually suggests to one skilled in the art that a coiled carbon nanotube having a non-hexagonal/hexagonal carbon ring ratio in the range of 0.1:1 to 1:1 is *not energetically possible*. Accordingly, Biro cannot render Applicants' claims 1-12 and 46-73 (as currently amended) obvious.

The Examiner rejected claims 1-12 under 35 U.S.C. § 103(a) as being obvious over Amelinckx *et al.* (Science, July 1994). Applicants submit that the novel physical features of claims 1-12 are nonobvious and hence patentable under §103 since Applicants' invention represents a departure from the teachings of Amelinckx.

One of ordinary skill in the art would not have selected the various elements from Amelinckx to create a coiled carbon nanotube having a non-hexagonal/hexagonal carbon ring ratio in the range of 0.1:1 to 1:1. "For a chemical compound, a prima facie case of obviousness requires structural similarity between claimed and prior art subject matter where the prior art gives reason or motivation to make the claimed compositions." *Yamanouchi Pharmaceutical Co., Ltd. v. Danbury Pharmacal, Inc.*, 231 F.3d 1339, 1343 (Fed. Cir. 2000). Amelinckx does not teach a coiled carbon nanotube with any specific structure. In fact, Amelinckx only suggests the possibility of non-hexagonal carbon ring presence as the reason for the random occurrence of curved nanotubes. Beginning on Page 4, the end of column 3, and continuing to page 5, Amelinckx provides:

"[L]arge stresses may induce the formation of pentagonal meshes in the graphite network to relieve part of the stresses. Such pentagonal meshes, which cause positive curvature (elliptic points), are present at +60° disclinations, that is, they are associated with the removal of a 60° wedge from the hexagonal network. On the other hand, graphite deforms by "kinking" when it is under compressive stresses parallel to the basal planes. *In general, the growth-induced stresses seem to be sufficiently*

*large to activate this mode of plastic deformation,...* However, part of the compressive stresses may also be relieved by the formation of heptagons associated with  $-60^\circ$  disclinations, that is, with the insertion of a  $60^\circ$  wedge that causes negative curvature (hyperbolic points). The occurrence of pentagon-heptagon pairs minimizes the long-range stresses. These consideration may readily be extended to helices." (emphasis added)

This dual suggestion for carbon nanotube curvature does not give reason or motivation to make a coiled carbon nanotube having a non-hexagonal/hexagonal carbon ring ratio in the range of 0.1:1 to 1:1. Accordingly, Amelinckx cannot render Applicants' claims 1-12 as obvious.

The Examiner rejected claims 1-12 under 35 U.S.C. § 103(a) as being obvious over Nakayama *et al.* (6,558,645). Applicants submit that the novel physical features of claims 1-12 are nonobvious and hence patentable under §103 since Applicants' invention represents a departure from the teachings of Nakayama.

Nakayama teaches a method for manufacturing carbon nanocoils which have an external diameter of 1000 nm or less. Nakayama does not disclose anything about the nanocoils' composition other than its external diameter. There is no suggestion about what causes the carbon nanotubes in Nakayama's method to coil. Accordingly, it would not have been obvious to one skilled in the art that at least some of the carbon nanocoils produced via Nakayama's method would possess a non-hexagonal/hexagonal carbon ring ratio in the range of 0.1:1 to 1:1. Accordingly, Nakayama cannot render Applicants' claims 1-12 as obvious.

In view of the foregoing, it is respectfully submitted that Applicants' claims 1-12 and 46-73 (as currently amended) are not properly rejectable as obvious over Biro, Amelinckx, or Nakayama '645, either singularly and in combination.

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**CONCLUSION**

Applicants believe that all of the present claims are in condition for allowance. Accordingly, entry and careful consideration of this Response and an early indication of allowance is hereby requested. If the Examiner believes there is any issue which could be resolved by a telephone conference or a personal interview, the Examiner is respectfully requested to contact the undersigned at the telephone number listed below.

Respectfully submitted,

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